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## BOX PATENT APPLICATION

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

PATENT

Agents Docket No. 94680-US

THE COMMISSIONER OF PATENTS AND TRADEMARKS

Washington D.C. 20231  
U.S.A

January 23, 1998

Dear Sir:

Submitted herewith for filing is a new patent application in  
the name of: John C. BURNS et al  
for: SWITCHED CONNECTIONS DIAGNOSTICS IN A SIGNALLING NETWORK

1. Enclosed are the following:

- 1.  Specification and claims 46 pages.
- 2.  Drawings 3 sheets of drawings (as attached to declaration).
- 3.  Filing fee (see 10 and 11 below)
- 4.  Unsigned Declaration.
- 5.  A verified statement to establish small entity status.
- 6.  An assignment.
- 7.  A certified copy of Canadian Patent Application

8. [ ] Preliminary amendment  
 9. [ ] Clean copy of application papers (unsigned)  
 10. The filing fee as calculated below

FOR	NO. FILED	NO. EXTRA	RATE	CALCULATIONS
TOTAL CLAIMS	6		\$22.00	\$ 132.00
INDEPENDENT CLAIMS	—		\$80.00	\$
MULTIPLE DEPENDENT CLAIMS				
BASIC FEE				\$ 922.00
TOTAL OF ABOVE CALCULATIONS				\$ 922.00
Reduction by 1/2 for filing by small entity				\$
TOTAL FILING FEE				\$ 922.00
FEE FOR RECORDING ASSIGNMENT				\$
TOTAL OF FILING AND RECORDING FEES				\$ 790.00

11. Checks in the amount of US\$790.00 and \$132.00 are enclosed. The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 13-1717. A duplicate copy of this sheet is enclosed.

Respectfully submitted

By:   
 Name: Richard J. Mitchell  
 Reg. No. 34519

MARKS & CLERK  
 P. O. Box 957, Station B  
 Ottawa, Ontario  
 Canada K1P 5S7 (613) 236-9561

**BOX PATENT APPLICATION**

**PATENT**

Agent's Docket No. 94680-US

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of )  
John C. BURNS et al )      BATCH NO:  
                      )

For: SWITCHED CONNECTIONS DIAGNOSTICS IN A SIGNALLING  
NETWORK

January 23, 1998

Commissioner of Patent and Trademarks

Washington, D.C. 20231

**TRANSMITTAL LETTER**

Sir:

Submitted herewith are the following documents:

- Patent Application Cover Sheet (in duplicate)
- Unsigned Declaration
- Specification and drawings of 49 pages
- Checks in the amount of \$790.00 and \$132.00

Respectfully submitted,

BY: Richard J. Mitchell

Richard J. Mitchell  
Reg. No. 34,519  
Agent of Record

MARKS & CLERK  
P. O. Box 957, Station B  
Ottawa, Ontario Canada K1P 5S7 (613) 236-9561

USA

Agent's Docket No. 94680-US

**DECLARATION FOR PATENT APPLICATION**

As a below named inventors, we hereby declare that:

Our residence, post office address and citizenship are as stated below next to our name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) for the subject matter which is claimed and for which a patent is sought on an invention entitled

**SWITCHED CONNECTIONS DIAGNOSTICS IN A SIGNALLING NETWORK**

the specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, ss1.56(a).

I hereby claim priority rights under Title 35, United States Code ss119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):	Priority claimed		
<u>2,195,893</u> (Number)	<u>CANADA</u> (Country)	<u>24/01/97</u> (Day/Month/Year)	<u>Yes</u>

I hereby claim the benefit under Title 35, United States Code, ss120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, ss112, I acknowledge the duty to disclose material information as defined in title 37, Code of Federal Regulations, ss1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Number)	(Filing date)	(Status)
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I hereby appoint the following agent to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

**Richard J. Mitchell, Reg. No. 34,519**

Direct all telephone calls to Tel: (613) 236-9561

Address all correspondence to: **MARKS & CLERK, 55 Metcalfe Street, Suite 1380, P.O. Box 957, Station B, Ottawa, Ontario Canada K1P 5S7**

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Inventor

Full name: **John C. BURNS**

Citizenship: Canadian Residence (City, State):Kanata, Ontario, Canada

Address: 1436 Houston Cres., Kanata, Ontario K2W 1B6 Canada

Signature:.....

Date:.....

**John C. BURNS**

Inventor

Full name: **Stephen C. BEWS**

Citizenship: Canadian Residence (City, State):Stittsville, Ontario, Canada

Address: 11 Kearnsley Way, Stittsville, Ontario K2S 1G8 Canada

Signature:.....

Date:.....

**Stephen C. BEWS**

Inventor

Full name: **Jonathan L. BOSLOY**

Citizenship: Canadian Residence (City, State):Kanata, Ontario, Canada

Address: 15 Parsons Ridge, Kanata, Ontario K2: 2M1 Canada

Signature:.....

Date:.....

**Jonathan L. BOSLOY**

Inventor

Full name: **David WATKINSON**

Citizenship: Canadian Residence (City, State):Kanata, Ontario, Canada

Address: 31 Ipswich Terrace, Kanata, Ontario K2K 2R5 Canada

Signature:.....

Date:.....

**David WATKINSON**

## SWITCHED CONNECTIONS DIAGNOSTICS IN A SIGNALLING NETWORK

### Field Of The Invention

5

This invention relates to the field of digital networks, for example, asynchronous transfer mode (ATM) networks and, more particularly, to a methodology for detecting and diagnosing switched connection failures in a 10 signaling network when attempting to setup a call.

### Background Of The Invention

Network switches, controlled by signaling software, 15 can dynamically setup end-to-end connections across the network, for instance, Switched Virtual Channel (SVC) or Soft Permanent Virtual Channel (SPVC) connections in an ATM network. Sometimes these connections fail to route successfully.

20

Today's signaling software provides very simple cause and diagnostics information to aid in trouble shooting failed call attempts. Often, the cause and diagnostics are inadequate to trouble shoot the root cause of the problem as 25 only a single reason is provided as to the failure. Much manual work, often involving more than one operations person, must be done to actually locate the root cause of the problem. This becomes very costly in terms of network resources and time.

30

More detailed connection diagnostics are required to aid in troubleshooting in these situations.

### Summary Of The Invention

An object of the present invention is to alleviate the prior art problem.

5        According to the present invention there is provided a method of diagnosing faults in a network having a plurality of nodes through which switched virtual connections can be established, comprising the steps of recording all attempts at establishing routes through the  
10      network; and analyzing the attempted routes to identify the source of a failure.

The switched connection diagnostics functionality, embodying the present invention, collects details in call processing messages for each switch and physical trunk visited plus rejection causes for every attempted route during the call setup phase. The collected information is returned in the call processing messages back to the source switch which in turn presents this information to network operators. These details enable the network operators to easily isolate and troubleshoot problems.

25      This invention enables signaling software to gather detailed information for a switched connection for every leg of a call setup rather than simply providing one reason as to routing failure, thus allowing quick problem resolutions with minimal effort.

30      The invention also provides a packet switched data communications network, comprising a plurality of interconnected network nodes; a plurality of users connected to at least some of said network nodes; means for attempting to establish virtual connections between users over a plurality of alternate routes through said network; and

means for recording, in a diagnostic mode, attempts at establishing routes through said network; and diagnostic means for analyzing said recorded attempts to identify the source of a failure.

5

#### Brief Description Of The Drawings

The invention will now be described in more detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 illustrates a communications network capable of establishing switched virtual connections;

Figure 2 illustrates diagnostics points of failure between two network switches;

Figure 3 illustrates diagnostics operation for a call trace of a successful call;

Figure 4 illustrates diagnostics operation for a call trace of a successful call with one node failure; and

Figure 5 illustrates diagnostics operation for a call trace of an unsuccessful call.

#### Detailed Description

In Figure 1, tgXY, where X, Y can be a node A, B, C, D, E represents a trunk group from the node X to the node Y and uX represents a user, i.e. a service subscriber, for a user network interface (UNI) at the node X. The nodes represented by the letters A to E are typical switches, such as, Newbridge Networks Corporation's 36170 switches. For

example, tgAB is the trunk group between switches A and B while uA and uD are users for the UNIs at respective nodes A and D.

5       A switched virtual channel (SVC) connection can be setup from Customer Premise Equipment 1 (CPE-1) to Customer Premise Equipment 2 (CPE-2) using users uA and uD for the calling and called addresses, respectively. Alternatively, a soft permanent virtual channel (SPVC) connection can be  
10    setup from the port on A where CPE-1 is attached at uA to the port on D where CPE-2 is attached at uD. If a routing problems occurs with either the SVC or SPVC connection setups, then the following steps should be taken to diagnose the problem depending on the type of connection.

15

SVC Case:

20    A customer at CPE-1 complains that its application is not functioning. The Service Provider turns on or activates the switched connection diagnostics for user uA, and instructs the customer to try the application again. The SVC connection setup is retried and switched connection diagnostics are collected. The results from the diagnostics are analyzed. By using the routing reject points, the  
25    Service Provider can locate and then correct the problem in the network. The Customer retries his application and is once again back in service.

SPVC Path Case #1 - Path is Waiting For Resources:

30

The Service Provider configures an SPVC path from user uA to user uD, and connects it. The path setup enters a *Waiting for Resources* state. The Service Provider initiates the switched connection diagnostics for the

specific problematic SPVC path. The SPVC path is retried and switched connection diagnostics are collected. The results from the diagnostics are analyzed. By using the routing reject points, the Service Provider can locate and 5 then correct the problem in the network. The SPVC path is retried. The call is completed and now enters the connected state.

SPVC Path Case #2 - Path is Connected:

10

The Service Provider configures an SPVC path from user uA to user uD, and connects it. The path enters the connected state. The Service Provider desires to determine the reason why the path took the route it did. The Service 15 Provider initiates the switched connection diagnostics for the specific SPVC path.

A bridge and roll optimize operation is performed on the path in order to gather switched connection diagnostics 20 for the path. International application PCT/CA97/00507, filed July 17, 1997, describes an implementation of the bridge and roll operation. This operation may be service affecting. However, if it is completed close to the 25 instance at which the path was first connected, there is a high probability that a more optimal route does not exist. The results are analyzed and routing reject points can then be further investigated to discern the cause of the path's present routing.

30

For a specific example of an application of the switched connection diagnostics, assume each switch has routing tables allowing uA to route an SVC to uD, and assume tgCD has no remaining bandwidth for the SVC. The SVC would start from A, use tgAB (assume primary trunk group) to get

to B, then proceed to use tgBC to get to C. Once at C, routing determines that tgCD is full and cranks back to B. B then cranks back to A as there are no other routes from B to D. A crankback occurs when a node passes a call back to a 5 previous node because it is unable to establish an onward connection. From A, the alternate trunk group tgAE is used. From E, tgEC is used, and again at C, routing determines tgCD is full and cranks back to E. E then cranks back to A as there are no other routes from E to D. Now A has 10 exhausted its routes so the SVC is released back to CPE 1.

Switched connection diagnostics record all routes attempted, i.e. A, tgAB, B, tgBC, C, reject reasons (cause and diagnostics), A, tgAE, E, tgEC, C, reject reasons. If 15 this list is followed, it can be determined that all roads lead to C, but there is NO usable route from C to D. The next step in the procedure is to focus diagnostics efforts at C to determine why tgCD is not usable.

Having regard specifically to SVC switched 20 connection diagnostics, SVCs are setup from user terminal to user terminal across the network. The point of attachment into the network from the user terminal defines the entry and exit points for the SVC. The point of attachment is 25 defined by a Call Processing User and its physical access i.e. its Trunk Group and the controlling signalling link. The switch routes an SVC from the User at the entry point to the User at the exit point. Routing tables, either static or dynamic, present in each node steer SVC setup messages 30 from the source User to the destination User. When routing chooses a route, i.e. a trunk group, the signalling message is sent out on the signalling link controlling the trunk group.

For SVCs, switched connection diagnostics are provided on a per User basis, and may be turned on (activated) or off (de-activated). The default for diagnostics is off, awaiting activation.

5

Every calling User that originates an SVC when switched connection diagnostics are activated will gather diagnostics information during call setup. This enables an end-user application to startup. The end-user has the 10 opportunity to signal potentially more than one SVC, and diagnostics will gather information on all SVCs originated from the application.

If diagnostics are not de-activated for a User after 15 an SVC routing problem has been diagnosed, then call setup performance for the User will be degraded as unwanted diagnostic information is collected for every call on the User. To guard against inadvertently leaving switched connection diagnostics active, the diagnostics are gathered 20 for a predetermined number of connection setups, for example the first 10 SVCs/SPVC paths setup for the User. After 10 calls for the User, the switched connection diagnostics de-activates itself.

25 If switched connection diagnostics are active for a User, and that User is the destination of a call, there is no effect. Switched connection diagnostics applies only to calls originated by a User.

30 In the case of SPVC switched connection diagnostics, the SPVC path definition contains the source, destination and administrative information for connection setup. The SPVC connection setup procedure initiates an SVC from the source endpoint towards the destination endpoint, and

therefor uses the same routing procedures as SVCs. In one reference model, the SPVC path endpoints are the ports on the switch where the customer premise equipment (CPEs) are attached. The Users, i.e. uA and uD, plus port and endpoint 5 information define the endpoints for the SPVC path. Again, routing uses routing tables, either static or dynamic, present in each node to steer SPVC setup messages from the source User to the destination User.

10       Switched connection diagnostics are provided on a per SPVC path basis, and may be turned on or off for the next SPVC path setup attempt. By default, the diagnostics are off. Once switched connection diagnostics have been turned on for an SPVC path, the next time the SPVC path is 15 setup, diagnostics information are collected for that SPVC.

20       When an SVC or SPVC call is being setup, routing attempts to route the call from source to destination. It uses loop detection and crankback optimizations to route the call. In this process, many different routes may be attempted. For every route tried, each switch and trunk group traversed is recorded. When a route is rejected, the reason is also recorded. A node management (Node Management Terminal Interface or NMTI) or network management system can 25 interpret this information to illustrate the routing points of failure.

30       Depending on the circumstances, switched diagnostics may provide more information when employed with hop-by-hop routing to setup a call, in comparison to source routing for call setup. A particular source routing technique is Private Network Node Interface (PNNI), wherein routing tables are regenerated and distributed to all nodes running PNNI. If a node becomes isolated because the physical

access to it fails, then all routes to the isolated node are removed from all routing tables. For example, in Figure 1, if node D goes off-line, then all routing tables (at nodes A, B, C and E) will not have an entry for the Users on node 5 D. Therefore, the routing of an SVC or SPVC path from uA to uD will fail at node A and never leaves the node. The switched connection diagnostics information will contain node A, and a cause indicating that the destination is unreachable. Otherwise, if the routing tables are static 10 hop-by-hop, much more diagnostic information typically would be gathered as routing attempts to use all configured routes that lead to D. All cause codes recorded at C will indicate that resources are unavailable.

15         Turning to Figure 2, illustrated is an exemplary signalling message exchange between two call control entities of respective network switches in order to setup a call. On the Newbridge 36170 switch, service cards perform the call control and signalling functions depicted. When 20 routing chooses a trunk group, an SVC/SPVC setup request is forwarded out the signalling link that controls the trunk group. Figure 2 illustrates the scenarios that can result between the switches:

25             1. Call control forwards the setup message to the local signalling stack.

               2. The local signalling stack rejects the message and returns failure to local call control.

30             3. The local signalling stack forwards the setup message to the remote signalling stack. The remote signalling rejects the setup message and informs the local

signalling stack of the rejection. The remote Call Control engine is not informed whatsoever.

4. Remote call control software in the switch on  
5 the remote side of the signalling link receives the SVC/SPVC  
setup message and processes it.

The first and fourth scenarios are processed by call control which logs diagnostics at this level. However, if  
10 scenarios two or three occur, then the diagnostic information must reflect this. If the local end rejects the call, then perhaps the service card servicing the signalling link is overburdened. If the remote end rejects the call, then perhaps the service card at the remote end is  
15 overburdened. This information pin-points perhaps a troubled service card.

Diagnostics are collected on a per service card basis. The service card, that manages the SVC User and SPVC path, collects switched connection diagnostics information  
20 when diagnostics is enabled. The service card can store switched connection diagnostics information for a predetermined number, say only 50 SVC or SPVC path setup attempts. The 50 most recent setup attempts are stored.  
25 This should be sufficient to allow several external network management requests to initiate switched connection diagnostics requests, then subsequently collect the results.

The enhanced signalling used to carry diagnostics information will now be described in more detail. Enhanced signalling is achieved by using information elements (IEs)  
30 defined to be in "Codeset 6", information elements specific to the local network.

The ITU-T Q.2931 signalling specification standardized coding format for information elements is followed. Therefore, all information elements contain an Information Element Identifier, Length and Instruction fields as shown below.

Information Element Identifier								Octet				
1	0	0	1	0	0	0	1	1				
Ext	Coding	Flag	Res	IE Action Ind				2				
Std								3				
Length								4				
Length (continued)												

The contents of the IE instruction field are always coded with a Flag of 'follow explicit instructions' and an IE Action Indicator of 'discard information element and proceed'.

New information element identifiers are allocated so as to not collide with "Codeset 0" identifiers. Codeset 6 information elements are preceded in a message by a Broadband Locking Shift information element. Non locking shift procedures are not supported.

8	7	6	5	4	3	2	1	Octet			
0	1	1	0	0	0	0	0	1			
Broadband Locking Shift IE Identifier											
1	0	0	1	0	0	0	1	2			
Ext	Coding	Fla	Res		IE Action Ind						
	Std	g									
Length of Broadband Locking Shift IE											
Length of Broadband Locking Shift IE (continued)											
1	0	0	0	0	1	1	0	5			
Ext	Spare			Codeset Identifier							

The purpose of the Locking Shift information element is to indicate the new active Codeset of succeeding

5 information elements. The specified Codeset remains active until another locking shift is encountered indicating the new active Codeset. Coding Standard (octet 2) is used to indicate ITU-T standardized coding. The Flag (octet 2) indicates to follow explicit instructions of the action 10 indicator. The IE action indicator (octet 2) indicates to discard information element and proceed. The Codeset Identifier (octet 5) identifies the Codeset, in this case Codeset 6.

15 Coding Rules as specified by the ITU-T and ATM Forum are followed. The following Table specifies information elements used for enhanced signalling. The identifier, maximum length and maximum number of occurrences are given for each information element.

Bits									Information Element	Max Length	Max no of
8	7	6	5	4	3	2	1			(Bytes)	Occurrences
0	0	0	0	0	0	1	1	Call Trace	1476	1	
0	1	1	0	0	0	0	1	Broadband locking shift	5	1	

There are four particular messages which are used

5 for enhanced signalling procedures: Connect, Setup, Release,  
and Release Complete messages. Each can include the  
Broadband Locking Shift information element, followed by a  
Call Trace information element which may have a length  
ranging from 20 to 1476 octets. Details of the Call Trace  
10 IE a given below.

A Connect message is used to return call trace information to the originating node on a Successful call completion. Both the Release and the Release Complete messages are used to transfer the reason for a routing failure. Information about the routing failure can be carried in either a Cause information element or optionally the Call Trace information element. Only the cause of the routing failure is carried in the Cause IE whereas the Call Trace IE carries complete information. The Setup message is used to collect call tracing information inside the call trace IE as the message traverses the network.

The purpose of the Call Trace IE is to trace the  
25 progress of a call as it traverses the network. The  
information relating to the node address, port and rejection  
causes is collected, as well as failure reasons and extra  
diagnostic information. The Call Trace IE contents form an  
ordered list representing node traversal information in  
30 chronological order. Each asterisked octet group represents

a sub-structure and may be repeated in the Call Trace IE, 0 or more times while appearing in any order.



Each Call Trace IE is comprised of four components: Call Transited Indication, Call Blocked Indication, Call Blocked After Transit Indication, and Call Completed Indication. Each of the aforementioned components has a 5 common structure. This structure consists of the component identifier, the length of the structure, and the component data.

The Call Transited Indication (octet group 5 of Call 10 Trace IE) denotes the successful traversal of a single node in the network. As shown in the format below, both node and port information are included.

Octet	8	7	6	5	4	3	2	1							
5.1	0	0	0	0	0	0	0	1							
Call Transited Indication															
Length															
5.2	0	0	0	0	1	0	0	1							
5.3	Reserved		Slot Format Identifier			Address Identifier									
5.4	Domain														
5.5	Domain (continued)														
5.6	Major Node Number														
5.7	Major Node Number (continued)														
5.8	Inbound Slot Number														
5.9	Inbound Slot Number (continued)														
5.10	Inbound Port Number														
5.11	Inbound Sub-Port														
5.12	Inbound Sub-Port (continued)														
5.13	0	0	0	0	Outbound Selection	0/1	Flag								
	Reserved				Type		Flag								
5.14	Outbound Slot Number														
5.15	Outbound Slot Number (continued)														
5.16	Outbound Port Number														
5.17	Outbound Sub-Port														
5.18	Outbound Sub-Port (continued)														

The following list details the individual fields of the Call Transited Indication sub-structure:

5

- Call Transited Indication (octet 5.1) - This field identifies the component type of the sub-structure, i.e., a route success indicator.

- Length (octet 5.2) - The length of the sub-structure is defined as the length of the entire sub-structure less the length and sub-structure identifier fields.

- Reserved (octets 5.3 and 5.13) - The reserved fields are ignored on receipt and coded as zero when added to the information element.

10

- Slot Format Identifier (octet 5.3) - The format of the inbound and outbound slots are specified by this field. For example "001" defines a 16-bit slot number consisting of an 11-bit shelf number and a 5-bit slot number.

15

- Address Identifier (octet 5.3) - The Address Identifier indicates the type of node address that follows. For example "001" represents a Newbridge specific Control 20 Packet Switching System (CPSS) address. Bit pattern "010" represents a Point Code. If the Address Identifier indicates a Point Code, the domain and major node number are replaced by a 22-octet binary number identifying the point code.

25

- Domain (octets 5.4-5.5) - This field defines the domain part of the CPSS address.

- Major Node Number (octets 5.6-5.7) - This field defines the major node number of the CPSS address.

30

- Slot Numbers (octets 5.8-5.9 and 5.14-5.15) - The first octet pair defines the ingress slot number of the

call, and the second octet pair defines the egress slot number of the call.

• Port Numbers (octets 5.10 and 5.16) - The  
5 respective fields identify the ingress and egress port numbers of the call.

• Sub-Port Number (octets 5.11-5.12 and 5.17-5.18)  
- The respective octet pair fields identify the inbound and  
10 outbound sub-ports. The interpretation of these fields are protocol dependent. For cell relay based protocols, the Sub-Port Number fields define the Virtual Path Identifier. The first octet pair defines the ingress virtual path of the call, and the second octet pair defines the egress virtual  
15 path of the call.

• Selection Type (octet 5.13) - This field identifies the outbound port/sub-port selection type as being either "001" which represents the preferred route or  
20 "010" which represents the primary alternate route.

• Flag (octets 5.13) - This field indicates an Assigning ('1') or Non-Assigning ('0') interface.

25 The Call Blocked Indication (octet group 6 of Call Trace IE) denotes the failure of a call to traverse a single node in the network. The sub-structure includes node and port information, the ingress port/sub-port as well as the reason for call blockage.

30

8	7	6	5	4	3	2	1	Octet
0	0	0	0	0	0	1	0	
Call Blocked Indication								6.1
Length								6.2
0	0	0	0	1	0	0	1	6.3
Reserved	Slot Format Identifier				Address Identifier			
Domain								6.4
Domain (continued)								6.5
Major Node Number								6.6
Major Node Number (continued)								6.7
Slot Number								6.8
Slot Number (continued)								6.9
Port Number								6.10
Sub-Port								6.11
Sub-Port (continued)								6.12
Cause Value								6.13
Diagnostics Cause Value								6.14
Diagnostics Cause Value (continued)								6.15
Length of Diagnostics								6.16
Diagnostics								6.17 etc.

The following list details the specific fields of the Call Blocked Indication sub-structure:

5

- Call Blocked Indication (octet 6.1) - This field identifies the component type of the sub-structure, i.e., a call blocked opcode.
- Length (octet 6.2) - The length of the sub-structure is defined as the length of the entire sub-

10

structure less the length and sub-structure identifier fields.

• Reserved (octet 6.3) - The reserved field is  
5 ignored on receipt and coded as zero when added to the information element.

• Slot Format Identifier (octet 6.3) - The format of the inbound slot is specified by this field. For example  
10 "001" defines a 16-bit slot number consisting of an 11-bit shelf number and a 5-bit slot number.

• Address Identifier (octet 6.3) - The Address Identifier indicates the type of node address that follows.  
15 For example "001" represents a Newbridge specific Control Packet Switching System (CPSS) address. Bit pattern "010" represents a Point Code. If the Address Identifier indicates a Point Code, the domain and major node number are replaced by a 22-octet binary number identifying the point code.

20 • Domain (octets 6.4-6.5) - This field defines the domain part of the CPSS address.

25 • Major Node Number (octets 6.6-6.7) - This field defines the major node number of the CPSS address.

• Slot Number (octets 6.8-6.9) - The octet pair defines the ingress slot number of the call.

30 • Port Number (octet 6.10) - This field identifies the ingress port number of the call.

• Sub-Port Number (octets 6.11-6.12) - This octet pair field identifies the inbound sub-port. The interpretation of this field is protocol dependent. For cell relay based protocols, the field defines the Virtual  
5 Path Identifier and the octet pair identifies the ingress virtual path of the call.

• Cause Value (octet 6.13) - The standard cause values are defined in Q.2610. These values define the  
10 reason for the routing failure. The cause value is associated with the port that has been most recently traversed.

• Diagnostics Cause Value (octets 6.14 and 6.15) -  
15 This field stores user defined (i.e., proprietary) cause values to aid network diagnostics.

• Length of Diagnostics (octet 6.16) - This defines  
20 the length of the Diagnostics field.

• Diagnostics (octet 6.17 etc.) - This field contains diagnostic information added to the sub-structure to aid in locating the network failures.

25 The Call Blocked After Transit Indication (octet group 7 of Call Trace IE) denotes a failure of a call to traverse a single node in the network. The sub-structure includes node and port information. In addition, incoming and outgoing port/sub-port (VPI) may be present. The Call  
30 Blocked After Transit Indication always contains information to indicate the cause of the route failure at that point in the network.

8	7	6	5	4	3	2	1	Octet						
0	0	0	0	0	0	1	1							
Call Blocked After Transit Indication								7.1						
Length								7.2						
0	0	0	0	1	0	0	1	7.3						
Reserved	Slot Format Identifier	Address Identifier												
Domain								7.4						
Domain (continued)								7.5						
Major Node Number								7.6						
Major Node Number (continued)								7.7						
Slot Number								7.8						
Slot Number (continued)								7.9						
Port Number								7.10						
Sub-Port								7.11						
Sub-Port (continued)								7.12						
Outbound Slot Number								7.13						
Outbound Slot Number (continued)								7.14						
Outbound Port Number								7.15						
Outbound Sub-Port								7.16						
Outbound Sub-Port (continued)								7.17						
Cause Value								7.18						
Diagnostics Cause Value								7.19						
Diagnostics Cause Value (continued)								7.20						
Length of Diagnostics								7.21						
Diagnostics								7.22 etc.						

The following list details the specific fields of the Call Blocked After Transit Indication sub-structure:

- Call Blocked After Transit Indication (octet 7.1)

- This field identifies the component type of the sub-structure, e.g., a call block after transit opcode.

5

- Length (octet 7.2) - The length of the sub-structure is defined as the length of the entire sub-structure less the length and sub-structure identifier fields.

10

- Reserved (octet 7.3) - The reserved fields are ignored on receipt and coded as zero when added to the information element.

15

- Slot Format Identifier (octet 7.3) - The format of the inbound and outbound slots are specified by this field. For example "001" defines a 16-bit slot number consisting of an 11-bit shelf number and a 5-bit slot number.

20

- Address Identifier (octet 7.3) - The Address Identifier indicates the type of node address that follows. For example "001" represents a Newbridge specific Control Packet Switching System (CPSS) address. Bit pattern "010" represents a Point Code. If the Address Identifier indicates a Point Code, the domain and major node number are replaced by a 22-octet binary number identifying the point code.

30

- Domain (octets 7.4-7.5) - This field defines the domain part of the CPSS address.

- Major Node Number (octets 7.6-7.7) - This field defines the major node number of the CPSS address.

- Slot Numbers (octets 7.8-7.9 and 7.13-7.14) - The respective octet pairs define the ingress and egress slot numbers of the call.

5

- Port Numbers (octets 7.10 and 7.15) - The respective fields identify the ingress and egress port numbers of the call.

10           • Sub-Port Numbers (octets 7.11-7.12 and 7.16-7.17)

- The respective octet pair fields identify the inbound and outbound sub-ports. The interpretation of these fields is protocol dependent. For cell relay based protocols, the fields define the Virtual Path Identifier. The first octet pair defines the ingress virtual path of the call, and the second octet pair defines the egress virtual path of the call.

- Cause Value (octet 7.18) - The standard cause values are defined in Q.2610. These values define the reason for the routing failure. The cause value is associated with the port that has been most recently traversed.

25           • Diagnostics Cause Value (octet 7.19-7.20) - This

- field stores user defined (i.e., proprietary) cause values to aid network diagnostics.

30           • Length of Diagnostics (octet 7.21) - This defines the length of the Diagnostics field.

- Diagnostics (octet 7.22 etc) - This field contains diagnostic information added to the sub-structure to aid in locating the network failures.

5 The Call Completed Indication (octet group 8 of Call Trace IE) denotes the successful traversal of a single node in the network. The sub-structure includes node and port information as shown below.

Octet	8	7	6	5	4	3	2	1
8.1	0	0	0	0	0	0	0	1
8.2	Call Completed Indication							
8.3	Length							
8.4	0	0	0	0	1	0	0	1
8.5	Reserved	Slot Format			Address			Identifier
8.6	Identifier							
8.7	Domain							
8.8	Domain (continued)							
8.9	Major Node Number							
8.10	Major Node Number (continued)							
8.11	Slot Number							
8.12	Slot Number (continued)							
8.13	Port Number							
8.14	Inbound Sub-Port							
8.15	Inbound Sub-Port (continued)							
8.16	0	0	0	0	Selection	0/1		
8.17	Reserved				Type	Fla		g
8.18	Slot Number							
	Slot Number (continued)							
	Port Number							
	Outbound Sub-Port							
	Outbound Sub-Port (continued)							

The following list details the specific fields of the Call Completed Indication sub-structure:

- 5           • Call Completed Indication (octet 8.1) - This field identifies the component type of the sub-structure, i.e., a call completed opcode.
- 10          • Length (octet 8.2) - The length of the sub-structure is defined as the length of the entire sub-structure less the length and sub-structure identifier fields.
- 15          • Reserved (octets 8.3 and 8.13) - The reserved fields are ignored on receipt and coded as zero when added to the information element.
- 20          • Slot Format Identifier (octet 8.3) - The format of the inbound and outbound slots are specified by this field. For example "001" defines a 16-bit slot number consisting of an 11-bit shelf number and a 5-bit slot number.
- 25          • Address Identifier (octet 8.3) - The Address Identifier indicates the type of node address that follows. For example "001" represents a Newbridge specific Control Packet Switching System (CPSS) address. Bit pattern "010" represents a Point Code. If the Address Identifier indicates a Point Code, the domain and major node number are replaced by a 22-octet binary number identifying the point code.

• Domain (octets 8.4-8.5) - This field defines the domain part of the CPSS address.

5       • Major Node Number (octets 8.6-8.7) - This field defines the major node number of the CPSS address.

10      • Slot Numbers (octets 8.8-8.9 and 8.14-8.15) - The first octet pair defines the ingress slot number of the call, and the second octet pair defines the egress slot number of the call.

15      • Port Numbers (octets 8.10 and 8.16) - The respective fields identify the ingress and egress port numbers of the call.

20      • Sub-Port Numbers (octets 8.11-8.12 and 8.17-8.18) - The respective octet pair fields identify the inbound and outbound sub-ports. The interpretation of these fields are protocol dependent. For cell relay based protocols, each field defines the Virtual Path Identifier. The first octet pair defines the ingress virtual path of the call, and the second octet pair defines the egress virtual path of the call.

25      • Selection Type (octet 8.13) - The Selection Type identifies outbound port/sub-port selection type, e.g., either "001" which represents the preferred route or "010" which represents the primary alternate route.

30      • Flag (octet 8.13) - This field indicates an Assigning ('1') or Non-Assigning ('0') interface.

In operation, call tracing is established at the exchange originating the call to be traced. At this point, a Call Trace IE is inserted into all calls to be traced. It is only explicitly enabled at the point of origin in the 5 network and is implicitly defined to be active by all other nodes in the network if the Call Trace IE is found to be present.

#### CALL TRACE OF SUCCESSFUL CALLS

10

##### 1. Actions Required at the Originating Exchange:

###### a) Initiating a Call Trace:

15 When a new call is initiated, the originating exchange (i.e., switch) checks for the presence of a Call Trace IE in the call setup message. If not existent, a Call Trace IE without components is inserted.

20 When an outgoing slot, port, or sub-port is selected, the Call Trace IE is modified before the setup message is forwarded. A 'Call Transited' component, containing the node address, ingress and egress slot/port/sub-port, is appended to the end of the IE. The 25 point of origin has now been traced as the setup message at the exchange.

30 A copy of the Call Trace IE with the 'Call Transited' structure is saved by the originating exchange.

###### b) Receipt of a Connect Message:

The originating exchange checks for the presence of the Call Trace IE in the Connect message. If the IE is

found, its contents contain a complete trace of the successful call across the network. The information can be used by the management layer for diagnostic information. The IE is not forwarded to the originating interface if it 5 does not support enhanced signalling.

If the IE is not found, a copy of the Call Trace IE that was saved is added to the Connect message.

10 2. Actions Required at a Transit Exchange:

a) Receipt of a Setup Message:

Upon successful route selection, the setup message 15 is examined for the presence of a Call Trace IE. If present, a 'Call Transited' component, containing the node address, ingress slot/port/sub-port and egress slot/port/sub-port is appended before the message is forwarded to the next exchange while a copy of the Call 20 Trace IE is locally saved.

b) Receipt of a Connect Message:

The Connect message is examined for the presence of 25 a Call Trace IE. If present, the message is forwarded to the preceding exchange without modification to the Call Trace IE.

If the Call Trace IE is absent, the exchange checks 30 for a previously saved copy. If such a copy exists, it is added without modification to the Connect message. The Connect message is then sent to the preceding exchange. In this case, a complete end-to-end call trace is not being performed.

## 3. Actions Required at the Destination Exchange:

## a) Receipt of a Setup Message:

5

Upon successful route selection, the setup message is examined for the presence of a Call Trace IE. If present, a 'Call Completed' component is appended to the Call Trace IE. A copy of the Call Trace IE is saved and the 10 Setup message is then forwarded to the destination. The Call Trace IE is removed if enhanced signalling has not been enabled at the destination interface.

## b) Receipt of a Connect Message:

15

The Connect message is examined for the presence of a Call Trace IE. If present, the message is forwarded to the preceding exchange without modification to the Call Trace IE.

20

If the Call Trace IE is absent, the exchange checks for a previously saved copy. If a copy exists, it is added to the Connect message before the message is forwarded to the preceding exchange.

25

CALL TRACE FOR UNSUCCESSFUL CALL ESTABLISHMENT

Three levels of information can be provided by a node at the point of failure: a cause value, a diagnostics cause value with user defined (proprietary) diagnostics, or a Call Trace IE. When a failure occurs, a Release or Release Complete message is generated by the exchange at the point of failure. The exchange will incorporate one of the aforementioned levels of failure information into the

message. As a result, the preceding node has the responsibility to process the failure information correctly.

1. Actions Required at the Originating Exchange:

5

a) Detection of a call failure at the originating node:

A Call Trace IE is inserted into the Setup message.

10 When the originating exchange detects that it is unable to process with the call, a 'Call Blocked' component is appended to the Call Trace IE. If enhanced signalling is enabled, the Call Trace IE is copied to the Call Rejection message which is sent to the originating user.

15

If the originating exchange is unable to include a copy of the Call Trace IE, normal call clearance procedures are followed.

20 b) Receipt of a Release or Release Complete message with a Call Trace IE:

25 The Call Trace IE is copied without modification to the Call Clearance message. The message is then sent to the originating user. The Call Trace IE contains a complete trace of the call and can be used by the management layer for local diagnostics.

30 c) Receipt of a Release or Release Complete message without a Call Trace IE:

The originating exchange determines if a Call Trace IE has been saved for this call. If the IE exists, a 'Call Blocked After Transit' component is appended. The IE is

then copied to the Call Clearance message which is then sent to the originating user.

d) Call Failure on receipt of Connect:

5

A call failure will occur if the exchange is unable to complete the call after receiving a Connect message.

If a Call Trace IE is present in the Connect 10 message, a 'Call Blocked' component is appended. If enhanced signalling is enabled, the component is then copied to the Call Trace IE that is sent to the originating user.

Otherwise, the saved Call Trace IE is copied to the 15 Release message. A 'Call Blocked' component is appended to the Call Trace IE.

If the originating exchange is unable to include a 20 copy of the Call Trace IE, normal call clearance procedures are followed.

2. Actions Required at a Transit Exchange:

a) Detection of a call failure at a Transit 25 Exchange:

At a transit exchange, a Call Trace IE is inserted into the Setup message. When the originating exchange detects that it is unable to process with the call, a 'Call 30 Blocked' component is appended to the Call Trace IE. If enhanced signalling is enabled, the Call Trace IE is copied to the Call Rejection message which is sent to the originating user.

If the originating exchange is unable to include a copy of the Call Trace IE, normal call clearance procedures are followed.

5           b) Receipt of a Release or Release Complete message with a Call Trace IE:

The Call Trace IE is copied without modification to the Call Clearance message. The message is then sent to the 10 originating user. The Call Trace IE contains a complete trace of the call and can be used by the management layer for local diagnostics.

15           c) Receipt of a Release or Release Complete message without a Call Trace IE:

The transit exchange determines if a Call Trace IE has been saved for this call. If the IE exists, a 'Call Blocked After Transit' component is appended. The IE is 20 then copied to the Call Clearance message which is then sent to the originating user.

25           d) Call Failure on receipt of Connect:

A call failure will occur if the transit exchange is unable to complete the call after receiving a Connect message.

If a Call Trace IE is present in the Connect 30 message, a 'Call Blocked' component is appended. If enhanced signalling is enabled, the component is then copied to the Call Trace IE that is sent to the originating user.

Otherwise, the saved Call Trace IE is copied to the Release message. A 'Call Blocked' component is appended to the Call Trace IE.

5 If the transit exchange is unable to include a copy of the Call Trace IE, normal call clearance procedures are followed.

### 3. Actions Required at the Destination Exchange:

10

a) Detection of a call failure at the Destination Exchange:

15

When the destination exchange determines that it cannot proceed with a call, then if possible, the Call Trace IE included in the Setup message should be copied to the Call Clearance message. A 'Call Blocked' component is then appended to the Call Trace IE.

20

In all failure cases at the destination exchange, it is possible for a 'Call Blocked' or 'Call Blocked After Transit' component to be appended after a 'Call Completed' component.

25

b) Receipt of a Release or Release Complete message with a Call Trace IE:

30

At the destination exchange, the Call Trace IE is copied without modification to the Call Clearance message. The message is then sent to the originating user. The Call Trace IE contains a complete trace of the call and can be used by the management layer for local diagnostics.

c) Receipt of a Release or Release Complete message without a Call Trace IE:

The destination exchange copies the Call Trace IE 5 that has been saved to the Call Clearance message being sent to the preceding exchange. A 'Call Blocked After Transit' component is appended to the Call Trace IE. This implies that the final Call Trace IE will always contain a 'Call Completed' component followed by a Call Trace component.

10

d) Call Failure on receipt of Connect:

A call failure will occur if the destination exchange is unable to complete the call after receiving a 15 Connect message.

If a Call Trace IE is present in the Connect message, a 'Call Blocked' component is appended. If enhanced signalling is enabled, the component is then copied 20 to the Call Trace IE that is sent to the originating user.

Otherwise, the saved Call Trace IE is copied to the Release message. A 'Call Blocked' component is appended to the Call Trace IE. If a 'Call Blocked' component is added, 25 it may succeed a 'Call Completed' component that was already appended to the Call Trace IE.

If the destination exchange is unable to include a copy of the Call Trace IE, normal call clearance procedures 30 are followed.

#### CALL TRACE ON CRANKBACK

1. Actions Required at the Originating Exchange:

130 a) Receipt of Release or Release Complete  
containing Crankback and Call Trace IE:

135 5 If an alternate route is available, the Call Trace  
IE is copied to the outgoing Setup message and a 'Call  
Transited' component is appended. A copy of the updated IE  
is saved locally.

140 10 If no alternate route is available, the Call Trace  
IE is copied to the Release message to be sent to the  
originating user.

145 15 b) Receipt of Release or Release Complete  
containing Crankback only:

150 20 If an alternate route is available, the Call Trace  
IE that was saved locally is copied to the outgoing Setup  
message. A 'Call Blocked After Transit' component is  
appended. When the alternate route is successfully  
selected, a 'Call Transited' component is then appended. A  
copy of the updated IE is again saved locally.

155 25 If an alternate route is unavailable, the Call Trace  
IE is copied to the Call Clearance message to be sent to the  
originating user and a 'Call Blocked After Transit'  
component is appended.

160 30 2. Actions Required at a Transit Exchange:

165 a) Receipt of Release or Release Complete  
containing Crankback and Call Trace IE:

At a transit exchange, if an alternate route is available, the Call Trace IE is copied to the outgoing Setup message and a 'Call Transited' component is appended. A copy of the updated IE is saved locally.

5

If no alternate route is available, the Call Trace IE is copied to the Release message to be sent to the originating user.

10           b) Receipt of Release or Release Complete containing Crankback only:

15           At a transit exchange, if an alternate route is available, the Call Trace IE that was saved locally is copied to the outgoing Setup message. A 'Call Blocked After Transit' component is appended. When the alternate route is successfully selected, a 'Call Transited' component is then appended. A copy of the updated IE is again saved locally.

20           If an alternate route is unavailable, the Call Trace IE is copied to the Call Clearance message to be sent to the originating user and a 'Call Blocked After Transit' component is appended.

25           3. Actions Required at the Destination Exchange:

a) Receipt of Release or Release Complete containing Crankback and Call Trace IE:

30           At the destination exchange, if an alternate route is available, the Call Trace IE is copied to the outgoing Setup message and a 'Call Transited' component is appended. A copy of the updated IE is saved locally.

If no alternate route is available, the Call Trace IE is copied to the Release message to be sent to the originating user.

5                   b) Receipt of Release or Release Complete containing Crankback only:

10                  At the destination exchange, if an alternate route is available, the Call Trace IE that was saved locally is copied to the outgoing Setup message. A 'Call Blocked After Transit' component is appended. When the alternate route is successfully selected, a 'Call Transited' component is then appended. A copy of the updated IE is again saved locally.

15                  If an alternate route is unavailable, the Call Trace IE is copied to the Call Clearance message to be sent to the originating user and a 'Call Blocked After Transit' component is appended.

20                  The balance of the figures demonstrate three different trace scenarios that incorporate the aforementioned operations. Symbols used in the diagrams represent the following:

25                  >User  
O                  Network Node  
ct                 Call Trace IE  
#                 Call Transmitted Indication  
\$                 Call Blocked Indication  
30                  @                 Call Blocked After Transit Indication  
!                 Call Completed Indication  
()                 'Contains'

Figure 3 illustrates the Call Trace feature activated for a successful call. The indicated messages are those which are relevant to the Call Trace feature.

5        The Setup message originates at user a and progresses through the network along nodes A, B, and E before arriving at user b. User b responds to Setup Message with a Connect message to indicate that the call has successfully completed.

10       Figure 4 provides a slight variation to the previous figure. In this instance, the Call Trace feature is activated for a successful call with one routing failure at a node. Again, only messages relevant to the Call Trace feature are shown.

15       The Setup message originates at user a and traverse a path along nodes A, C, and B. At node B a routing failure occurs. The Setup message then transverses a path from B through nodes C, D and E until a successful call completion is reached at user b. A Connect message is then sent back through nodes E, D, C, and A to user a.

20       Figure 5 depicts a call failure that is the result of multiple node failures. This scenario assumes that route D-E is Out of Service (OOS) and cannot be used to route the call.

25       The call is initiated from user a through node A. The message progresses by the preferred route to node B. Node B rejects the call due to a resource problem, but does not include a Call Trace IE. The call progresses to node D when the alternate route A-D is selected. Node D also rejects the call. The final Call Trace IE in the Release

message from node D contains information of the 2 node failures.

Those skilled in the art will recognize that various  
5 modifications and changes could be made to the invention  
without departing from the spirit and scope thereof. It  
should therefore be understood that the claims are not to be  
considered as being limited to the precise embodiments set  
forth above, in the absence of specific limitations directed  
10 to each embodiment.

We claim:

1. A method of detecting and diagnosing faults in a network having a plurality of nodes through which switched virtual connections can be established, comprising the steps of:
  - a) recording all attempts at establishing routes through the network; and
  - b) analyzing the attempted routes to identify the source of a failure.
2. A method as claimed in claim 1, wherein diagnostics data are gathered for each attempted route.
3. A method as claimed in claim 2, wherein said diagnostics data include the location and nature of said failure.
4. A method as claimed in claim 2, wherein said diagnostics data are included in a message propagated through the network.
5. A method as claimed in claim 4, wherein said diagnostics data are included in an information element (IE) field forming part of said message.
6. A method as claimed in claim 1, wherein for each attempt to establish a route through the network, diagnostics data pertaining to each switch and trunk group traversed is recorded.
7. A method as claimed in claim 1, wherein said network is an ATM network, said nodes comprising ATM switches.

8. A method as claimed claim 1, wherein said switched connections are switched virtual channel or soft permanent virtual channel connections.

9. A method of detecting and diagnosing faults in a  
5 network having a plurality of nodes through which switched virtual connections can be established, comprising the steps of:

a) entering a diagnostics mode for a given user when a suspected fault is detected;

10 b) attempting to establish a virtual connection originating at said given user through the network to a destination user via a plurality of alternate routes;

c) collecting diagnostics data for each attempted route through the network to said destination user; and

15 d) analyzing the said diagnostics data to identify the source of a failure.

10. A method as claimed in claim 9, wherein said diagnostics data is propagated through the network in a message.

20 11. A method as claimed in claim 10, wherein said diagnostics data include the nature and location of said failure.

12. A method as claimed in claim 10, wherein the call diagnostics data are returned the originating user.

25 13. A method as claimed in claim 9, wherein said diagnostics mode is automatically deactivated after a predetermined number of connection setups originating from said given user.

14. A method as claimed in claim 9, wherein said diagnostics data are carried in an information element of a message.

15. A method as claimed in claim 14, wherein said 5 information element is a call trace element.

16. A method as claimed in claim 15, wherein said call trace element includes a call transited field and a call blocked field.

17. A method as claimed in claim 16, wherein said call 10 transited fields and said call blocked fields include data identifying at least domain and node number of a node encountered on an attempted virtual connection.

18. A method as claimed in claim 17, wherein said call transited and call blocked fields also include data 15 identifying slot number and port number of an encountered node.

19. A method as claimed in claim 17, wherein said call blocked field contains data relating to the nature of a routing failure.

20. 20. A method as claimed in claim where said nodes contain hop-by-hop routing tables.

21. A packet switched data communications network, comprising:

- a) a plurality of interconnected network nodes;
- 25 b) a plurality of users connected to at least some of said network nodes;
- c) means for attempting to establish virtual connections between users over a plurality of alternate

routes through said network;

    d) means for recording, in a diagnostic mode, attempts at establishing routes through said network; and

    e) diagnostic means for analyzing said recorded

5 attempts to identify the source of a failure.

22. A packet switched data communications network as claimed in claim 21, wherein said nodes include service cards having a call control unit and a signalling stack for setting up a virtual connection, and a service card managing 10 a virtual connection collects diagnostics information for said recorded attempts at establishing routes through said network.

23. A packet switched network as claimed in claim 21, wherein each node comprises means for returning to an

15 originating user, in the diagnostic mode, detailed data relating to the progress of an attempted connection through that node.

24. A packet switched network as claimed in claim 23,

wherein each node comprises means for inserting said

20 detailed data into an information element of a message returned to an originating user.

25. A packet switched network as claimed in claim 24,

further comprising a Node Management Terminal Interface adapted to analyze said detailed data.

25 26. A packet switched network as claimed in claim 21, wherein said switches are ATM switches.

Abstract Of The Invention

A method is disclosed for detecting and diagnosing faults in a network. The network has a plurality of nodes 5 through which switched virtual connections can be established. First, all attempts at establishing routes through the network are recorded. Then, the location of a failure is determined by analyzing the attempted routes.

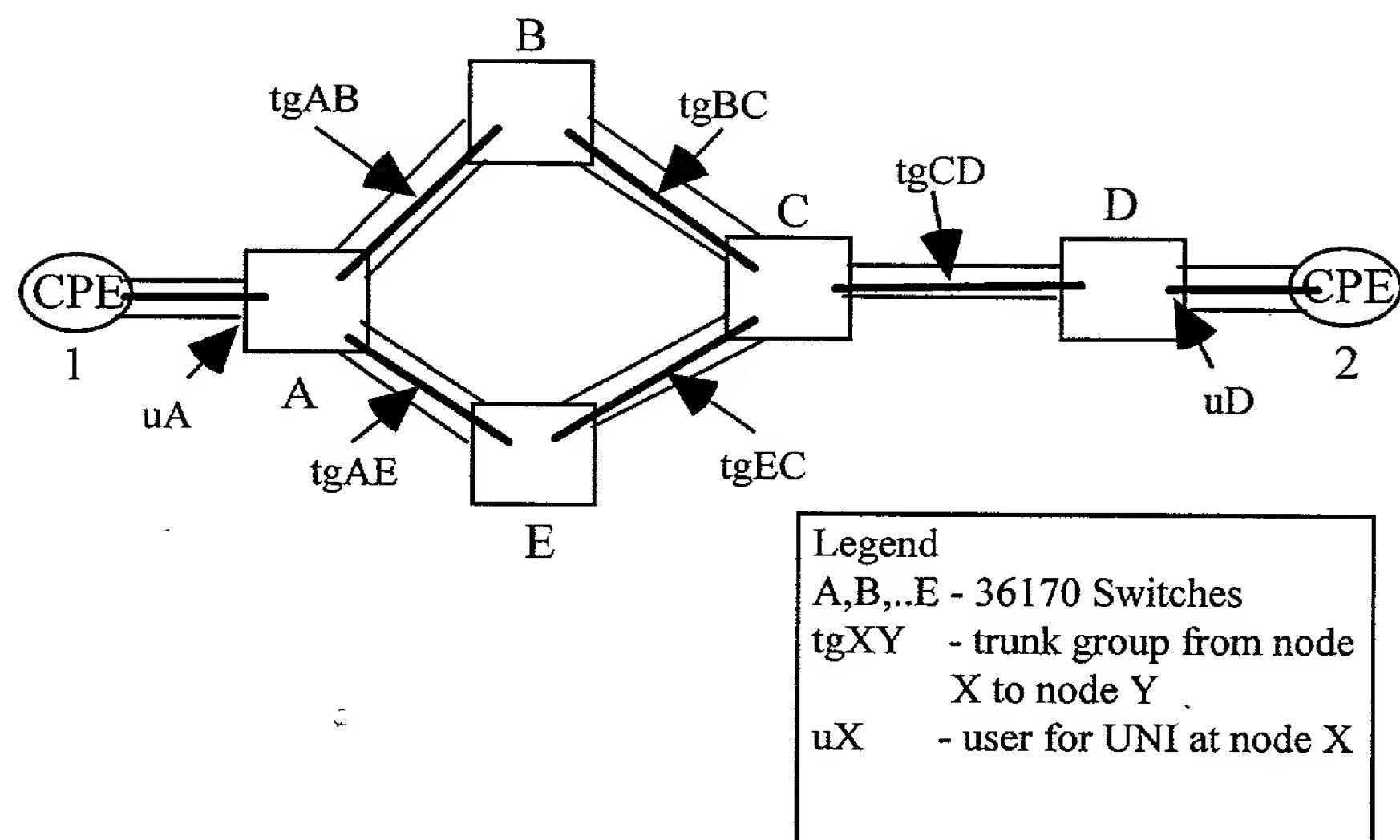


Figure 1

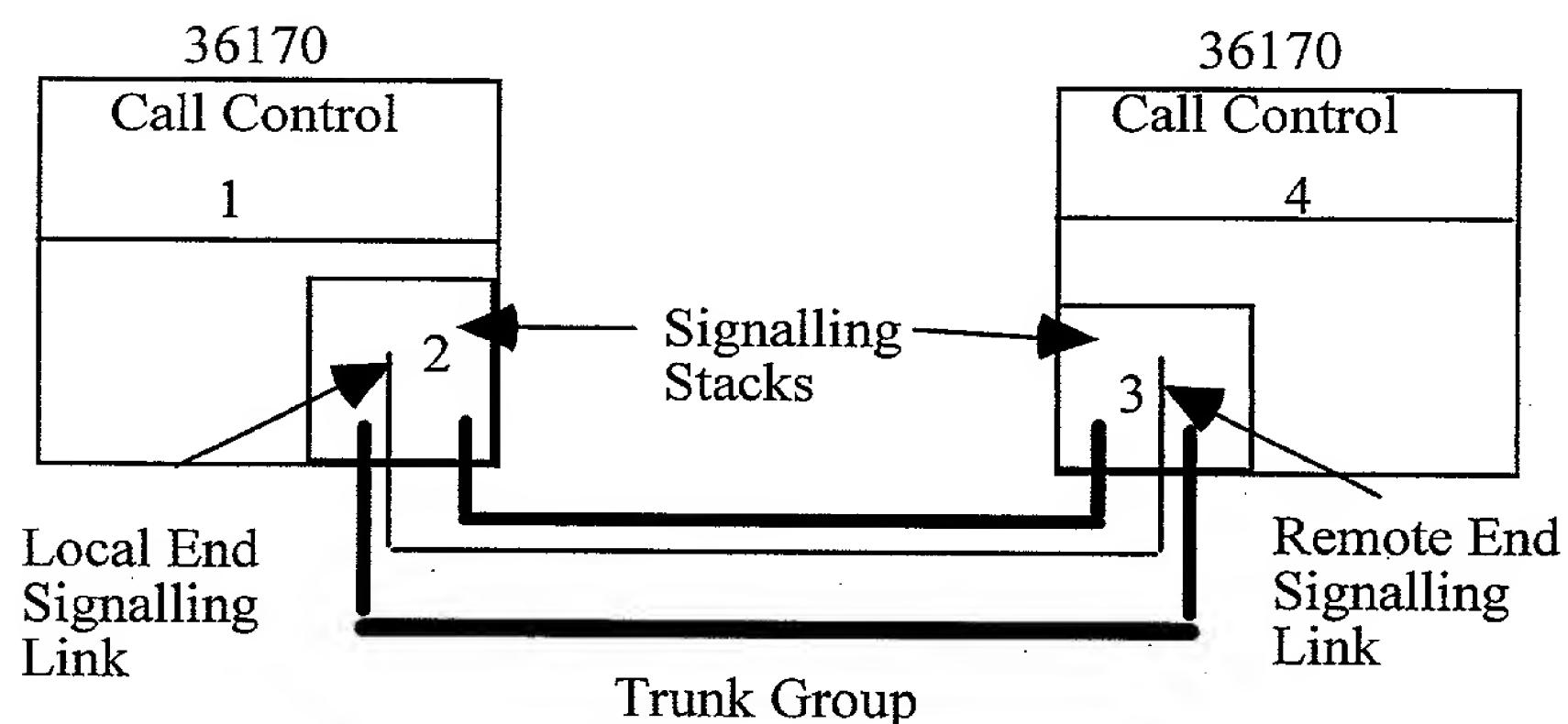


Figure 2

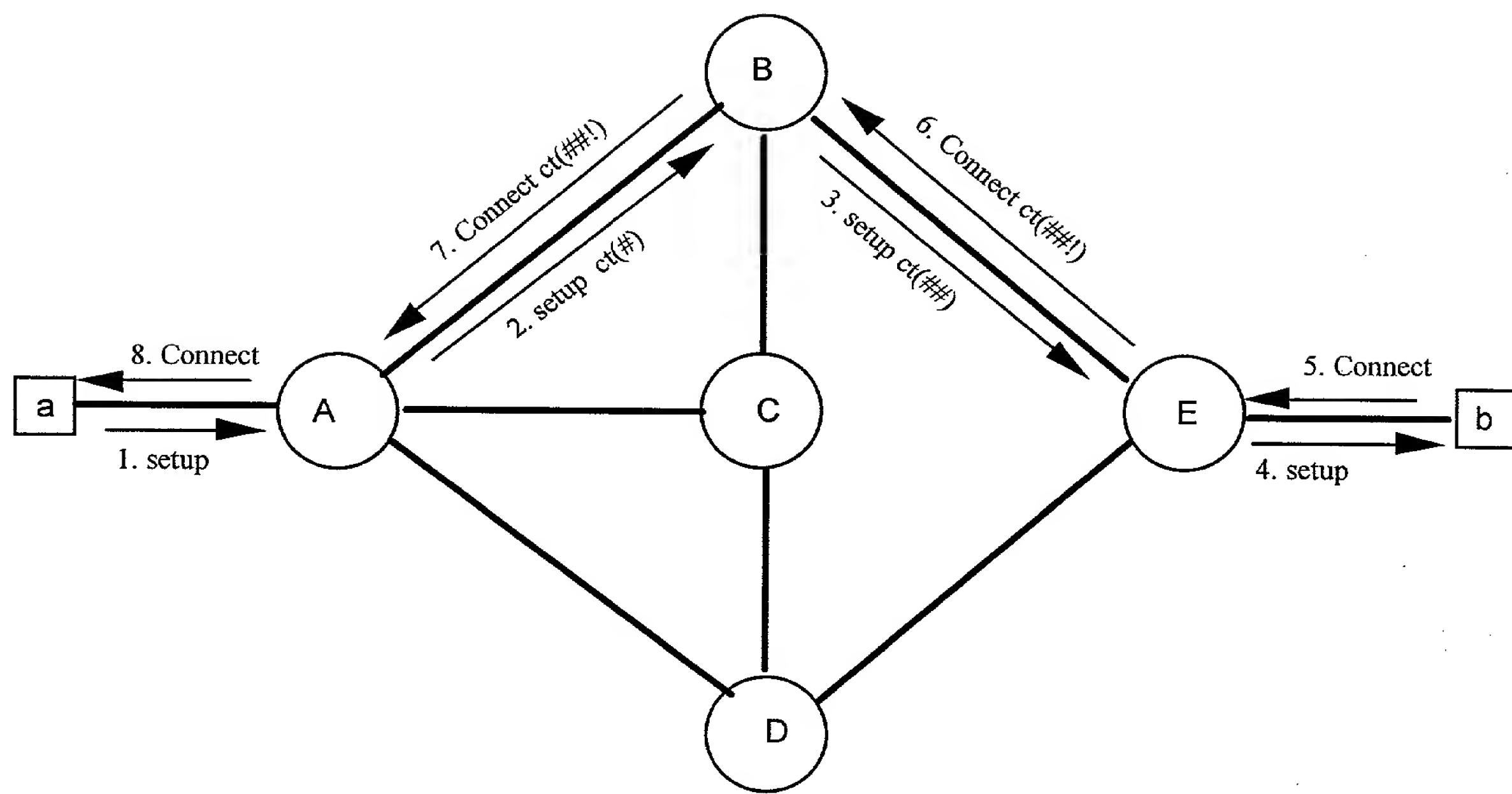


Figure 3

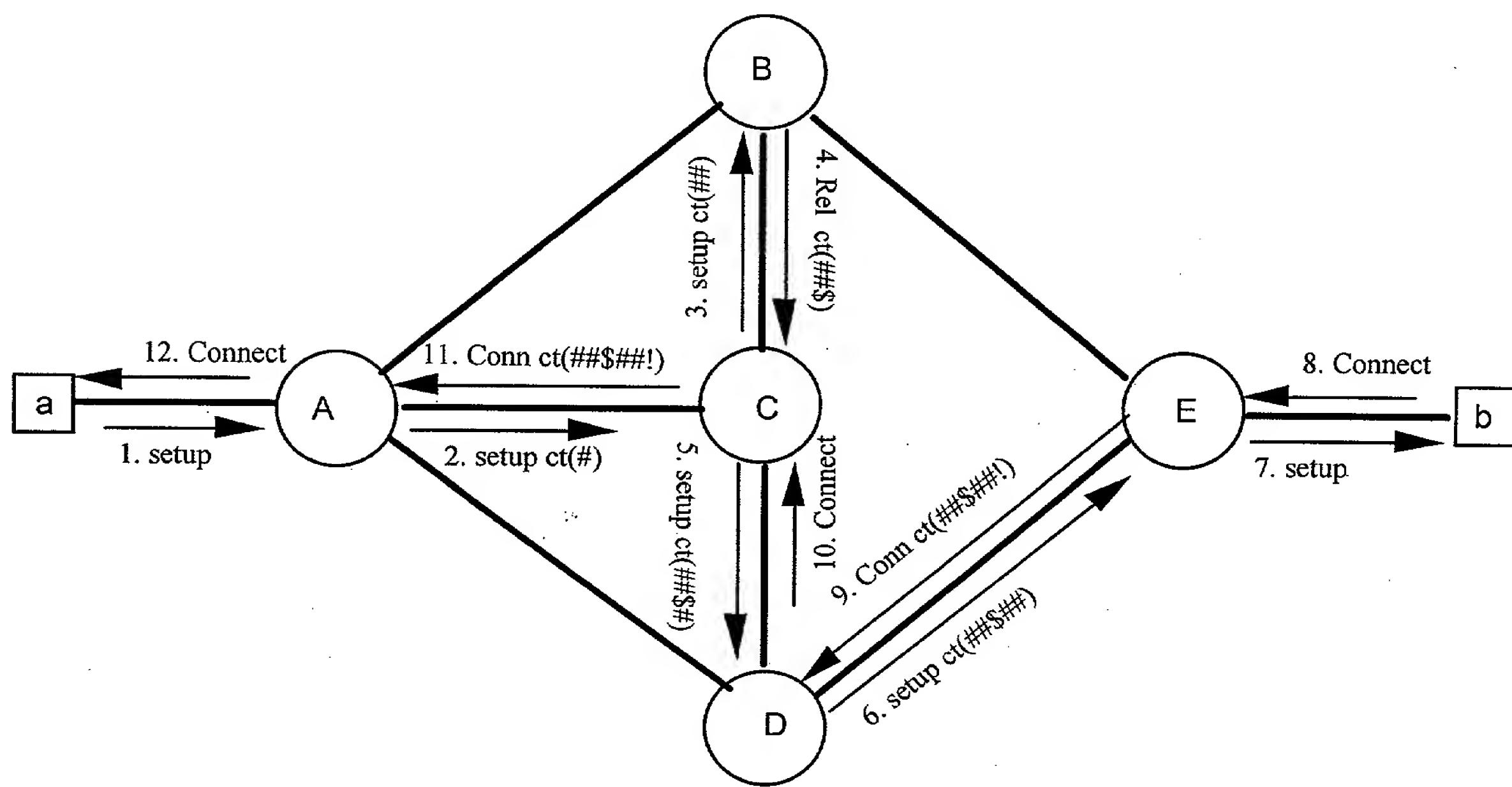


Figure 4

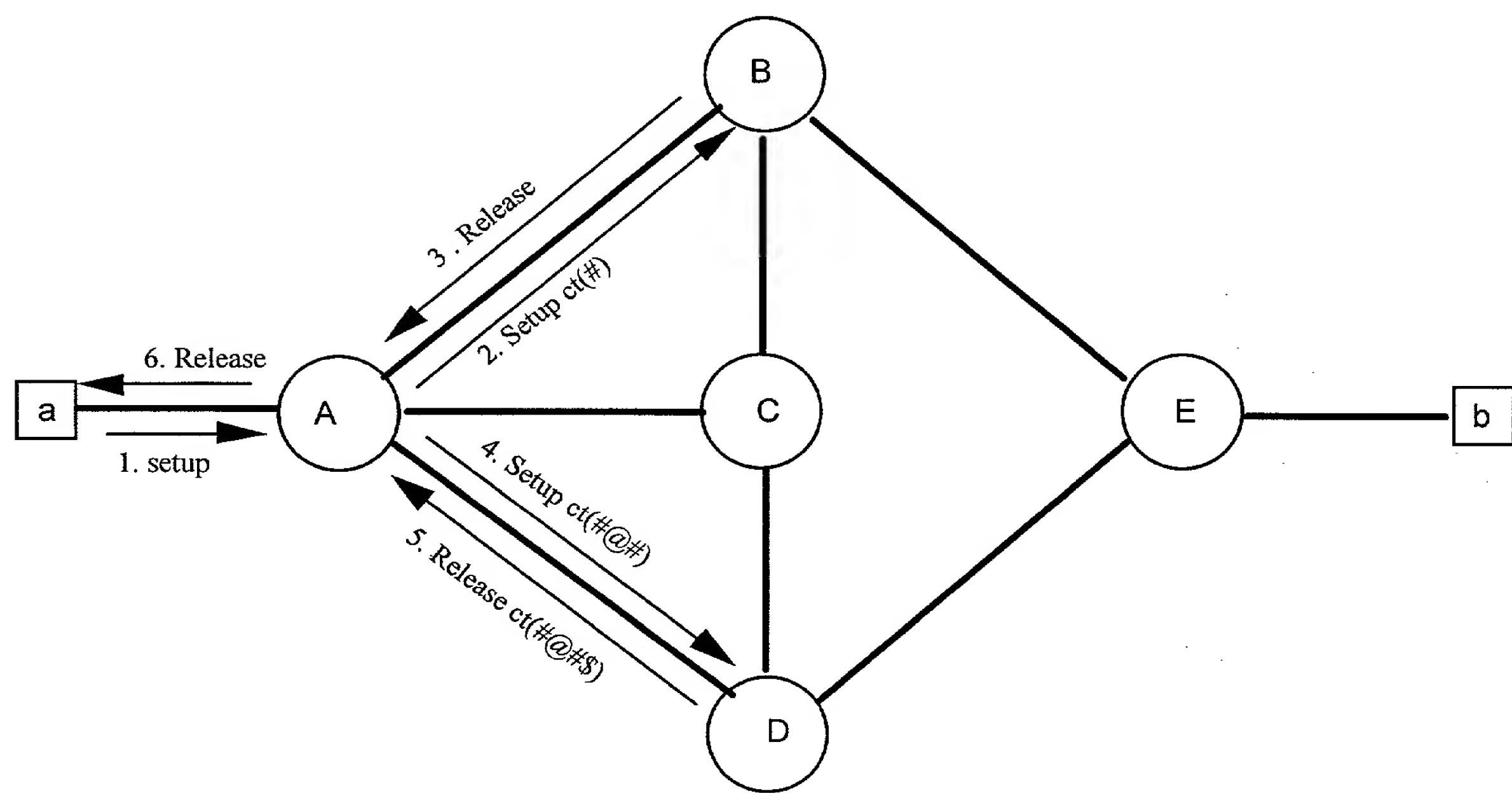


Figure 5